CLAIMS

1. Apparatus for monitoring in real time the movement of a plurality of substances in a mixture, the apparatus comprising an X-ray scanner arranged to make a plurality of scans of the mixture over a monitoring period to produce a plurality of scan data sets, and control means arranged to analyse the data sets to identify volumes of each of the substances and to measure their movement.

2. Apparatus according to claim 1 arranged, on each scan, to produce a data set relating to a layer of the mixture.

3. Apparatus according to claim 2 arranged to define a plurality of volume elements in said layer and to use a measure of the X-ray attenuation in each of said volume elements to form the data set.

4. Apparatus according to claim 2 or claim 3 wherein the control means is arranged to use the data sets to determine the amount of at least one of the substances in said layer.

5. Apparatus according to claim 4 wherein the control means is arranged to use the data sets from each of the scans to determine a time averaged value of the amount of said at least one substance.

6. Apparatus according to any of claims 2 to 5 wherein the scanner is arranged to produce data sets relating to a plurality of layers of the mixture, the layers being in different positions from each other.

7. Apparatus according to claim 6 wherein the control means is arranged to use the data sets relating to said plurality of layers to measure movement of at least one of the substances.

8. Apparatus according to claim 7 wherein the control means is arranged to track the movement of regions of said substance through the plurality of layers to determine a flow velocity of said substance.

9. Apparatus according to any foregoing claim wherein the control means is arranged to measure the movement of a region of a first one of the substances, to determine a measure of the buoyancy of said region relative to at least one other substance, and to measure the movement of said at least one other substance using the movement of said region and said buoyancy.

10. Apparatus according to any foregoing claim wherein the control means is arranged to define a model for calculating a parameter of movement of the substances on the basis of a number of variables, to produce a measured value of the parameter from the scan data sets, and to determine at least one of said variables from the measured value and the model.

11. Apparatus according to any foregoing claim wherein the control means is arranged to determine a flow rate of at least one of the substances, the flow rate being defined as the amount of said substance flowing through a predetermined region in a predetermined time.

12. Apparatus according to any foregoing claim wherein the control means is arranged to analyse a scan data set in two stages, one stage providing a lower spatial resolution and higher contrast resolution than the other.

13. Apparatus according to claim 12 wherein the control means is arranged to use the higher spatial resolution analysis to identify volumes

of a first of said substances and to use the higher contrast resolution analysis to distinguish between volumes of two further substances.

14. Apparatus according to claim 13 wherein the control means is arranged to use the high spatial resolution analysis to adjust a measure of X-ray attenuation, of volume elements defined in the low spatial resolution analysis, to account for the presence in said volume elements of the first substance.

15. Apparatus according to any foregoing claim wherein the scanner is arranged to be placed around a pipe to measure the movement of the substances through the pipe.

16. Apparatus according to any foregoing claim further comprising display means arranged to display an image of the mixture controlled by the control means.

17. Apparatus according to claim 16 wherein the display means is arranged to display a video image of the mixture.

18. A method of monitoring in real time the movement of a plurality of substances in a mixture, the method comprising making a plurality of X-ray scans of the mixture over a monitoring period to produce a plurality of scan data sets, and analysing the data sets to identify volumes of each of the substances and to measure their movement.

19. A method according to claim 18 wherein, on each scan, a data set is produced relating to a layer of the mixture.

20. A method according to claim 19 comprising defining a plurality of volume elements in said layer and using a measure of the X-ray attenuation in each of said volume elements to form the data set.

21. A method according to claim 19 or claim 20 wherein the data sets are used to determine the amount of at least one of the substances in said layer.

22. A method according to claim 21 wherein the data sets from each of the scans are used to determine a time averaged value of the amount of said at least one substance.

23. A method according to any of claims 19 to 22 wherein data sets are produced relating to a plurality of layers of the mixture, the layers being in different positions from each other.

24. A method according to claim 23 wherein the data sets relating to said plurality of layers are used to measure movement of at least one of the substances.

25. A method according to claim 24 wherein the movement of regions of said substance through the plurality of layers is tracked to determine a flow velocity of said substance.

26. A method according to any of claims 18 to 25 wherein movement of a region of a first one of the substances is measured, a measure of the buoyancy of said region relative to at least one other substance is determined, and the movement of said at least one other substance is measured using the movement of said region and said buoyancy.

27. A method according to any of claims 18 to 26 wherein a model is defined for calculating a parameter of movement of the substances on the basis of a number of variables, a measured value of the parameter is produced from the scan data sets, and at least one of said variables is determined from the measured value and the model.

28. A method according to any of claims 18 to 27 wherein a flow rate of at least one of the substances is determined, the flow rate being defined as the amount of said substance flowing through a predetermined region in a predetermined time.

29. A method according to any of claims 18 to 28 wherein a scan data set is analysed in two stages, one stage providing a lower spatial resolution and higher contrast resolution than the other.

30. A method according to claim 29 wherein the higher spatial resolution analysis is used to identify volumes of a first of said substances and the higher contrast analysis is used to distinguish between volumes of two further substances.

31. A method according to claim 30 wherein the high spatial resolution analysis is used to adjust a measure of X-ray attenuation, of volume elements defined in the low spatial resolution analysis, to account for the presence in said volume elements of the first substance.

32. A method according to any of claims 18 to 31 carried out using a scanner placed around a pipe to measure the movement of the substances through the pipe.

33. Apparatus for monitoring in real time the movement of a plurality of substances in a mixture substantially as described herein with reference to the accompanying drawings.

34. A method of monitoring in real time the movement of a plurality of substances in a mixture substantially as described herein with reference to the accompanying drawings.